User’s manual for digital plotter

Summary

Introduction

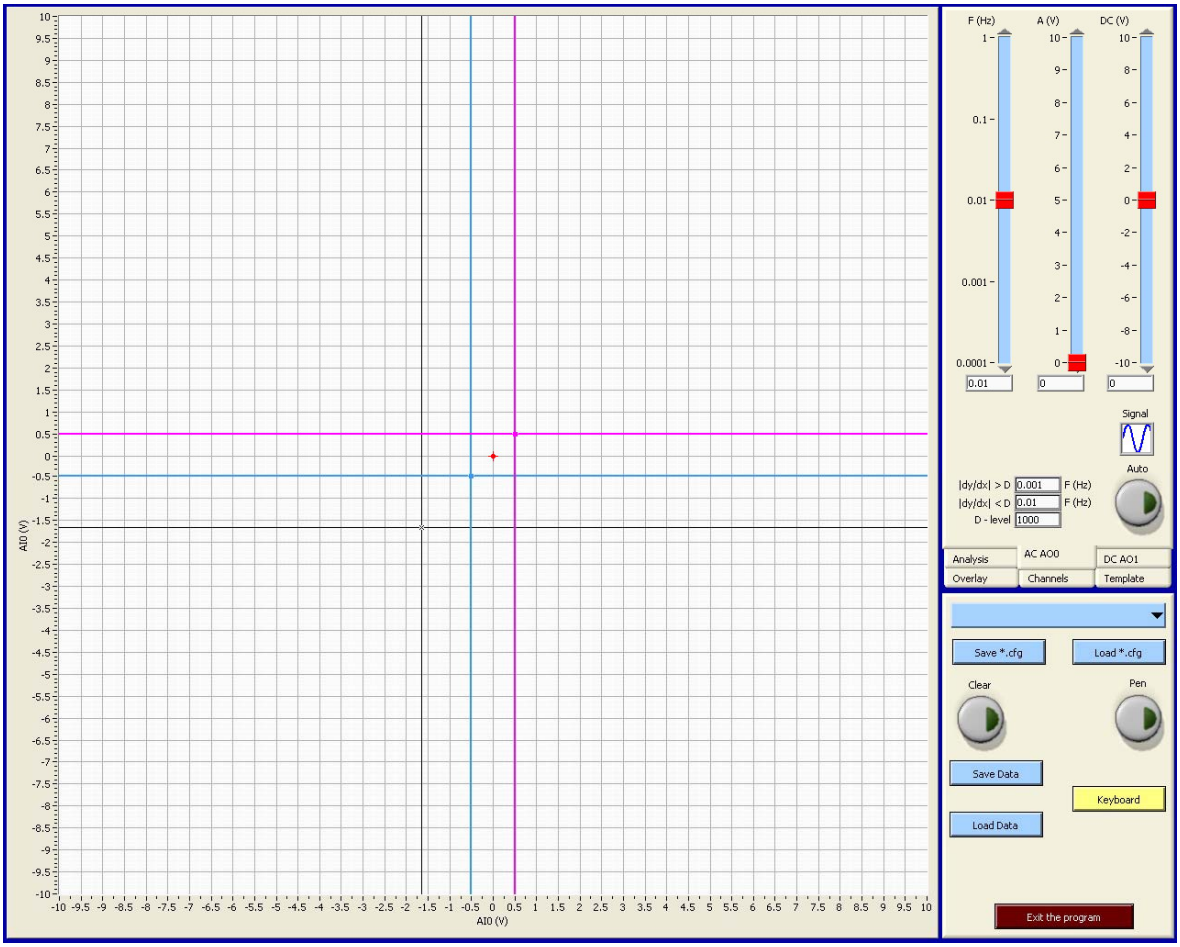
One of our customers has suggested replacing analog plotters by electronic data processing facilities. These “digital” plotters will be used in the production of servovalves to plot different curves of their static performances and dynamic response. These facilities may be also used in development tests of servovalves and prototype perfecting. In addition, they provide for optimum data storage, automatic calculation of the valve performances with print-out of the obtained results and plotting several curves simultaneously.

The customer charged Dietz automation GmbH with implementing this project. The customer will have an equipment which will bring up to a higher level the quality and productivity of his production.

This manual describes the general way of application of these facilities. We recommend reading it before pressing keys and buttons.

General description

When starting the program ValveExpert-Plotter, the page will open which was last in use before the computer was closed. If you are going to test the same model of servovalves, you may start testing without opening the required test configuration or reconfiguring anything.



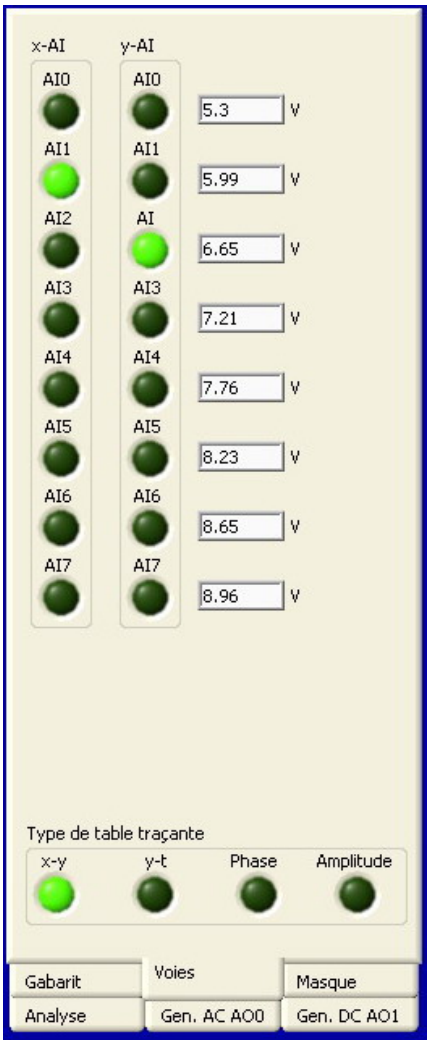
The figure above shows the page of the alternating current generator.

This page provides the access to other pages such as:

- «Analyze» to perform analyses and to display the results thereof
- «Gén. AC AO0» to generate the command signal to the servovalve under test
- «Gén. DC AO0» to generate other command signals (for example, to control supply pressure)
- «Gabarit» to enter tolerance values
- «Voies» to enter different measurements and their units (pressure in bars, current in mA and so on)
- «Masque» to allow the access to the page which store different templates for printing test results on the Excel diagram.

Inputs and outputs

There are 8 analog inputs AI and 2 analog outputs AO.
Each input/output ranges from -10 to +10 volts.
Each input/output has to be calibrated as a function of the parameter to be measured.



The page above shows the input/output configuration to provide for the following analysis functions (for a flow control servovalve):

1. AI0 for command signal in mA
2. AI1 for supply pressure Ps in bar
3. AI2 for return pressure Pr in bar
4. AI3 for control pressure Pa in bar
5. AI4 for control pressure P_B in bar
6. AI5 for pressure differential (P_B-Pa) in bar
7. AI6 for flow Q in l/min
8. AI7 for position transducer signal in V

In case of a specific test it is necessary to combine the inputs/outputs in a way to represent the results of this test.

The operation is similar to the ordinary x – y plotter.
The left column is intended for the x axis.
The right column is intended for the y axis.

Example.
You need the flow curve plot of a servovalve.
Therefore, you take the AI0 input in the left column for x axis which will be used for command signals to the servovalve in мA.
You take the AI6 input in the right column for y axis, which will be used for the flow of the servovalve in l/min.

Then you choose the x – y plotter and define the scale of both axes as a function of the desired measurement range for the command signals and expected flow values which correspond to these signals. This being done, you open the «Gén. AC AO0» page. The procedure seems to be long and complicated, but you do it only once for every servovalve model. Once all the data are entered, this configuration is saved. A .cfg file will be created, and every time, when you need to run this test, you open this memorized file: all the scales and adjustments reappear, and you can start testing at once.

A big advantage of these facilities consists in simultaneous saving of all the 8 inputs. If, for example, the test shows that the flow of a servovalve is lower than you expects, you may get displayed the value of the supply pressure as a flow function to see whether this pressure has been stable when the test was run.
Another example proves the importance of the simultaneous saving of several inputs:

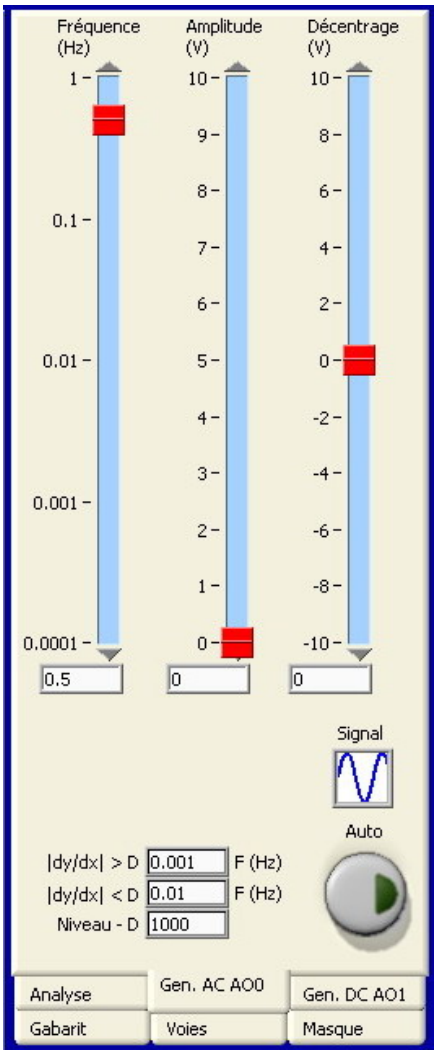
- You are saving the differential pressure curve of a servovalve
- At the same time the internal leakage curve of this servovalve is saved, the configuration of this test being identical to the test described above, i.e the control ports are closed
- In addition, the spool position curve is saved for servovalves equipped with spool position transducer
- Furthermore, Va and Vb tensions may be also saved.

In total, 5 diagrams may be possible with one test.

«Gén. AC AO0» alternating current generator

The data acquisition system has 2 analog outputs. An AC generator is connected to the AO0 output. This generator has 2 functions:

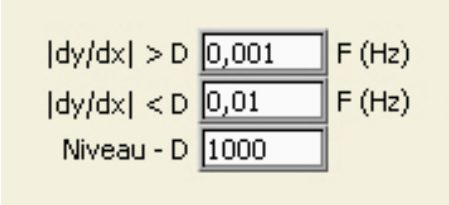
- It changes the command signal to be applied to the servovalve for providing its flow or pressure curve
- It generates the command signal to be applied to the servovalve when the frequency response is testing.



The AC generator has the following controls:

- «Signal», to enter the signal wave: sinus, triangular, square, saw
- «Fréquence», to enter the test frequency or frequency range
- «Amplitude», to enter the output signal amplitude. The possible values are the function of the input calibration.
- «Décentrage», to adjust the null of the output signal.
  Attention: the null shift value plus the amplitude value shall not exceed the maximum value of this input.

Speed of command signal change-over:



This control allows gain in time and quality when measuring parameters who's gain varies sensibly. This applies particularly to the servovalve pressure gain curve and internal leakage curve..

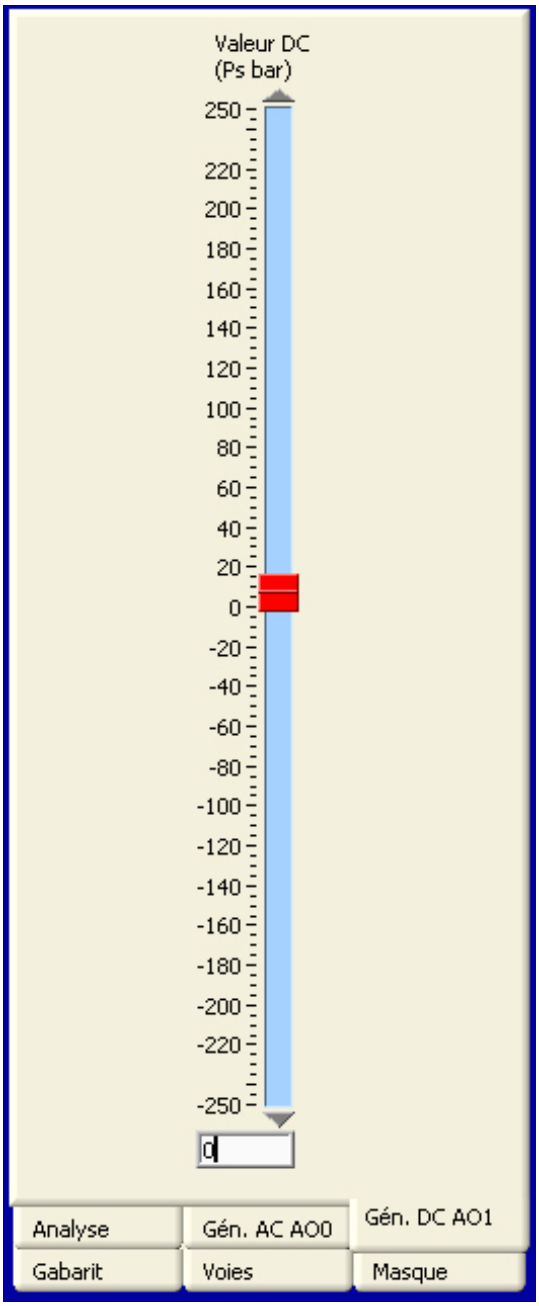
Indeed, the servovalve pressure gain is normally very high. The ordinary way consists in changing the command signal very slowly not to falsify measurements because of too fast change-over. The measurement accuracy is observed but it takes too much time to run the test, especially at the stage when the pressure does not vary due to its saturation. For us this way is not acceptable as we run three tests at the same time: differential pressure, internal leakage and spool position. The test would be too long, since the differential pressure keeps being saturated for 90% of time. During this period it is possible to change over to signals faster.

It is quite different with these facilities. They allow to decrease the time of changing the command signals as the function of the data curve derivative. The adjustment will require some skill, and it has to be done for every servovalve model to be tested. The following controls are available:

- «Niveau-D» to enter the increment/decrement value which shall start changing the speed of the command signal change-over. For example, if the servovalve pressure gain is 50.000 psi/mA, it may be defined that if the change-over value exceeds 1000, the speed becomes lower.
- [dy/dx]<D_____F(Hz) to enter the value of the command signal passage. The figure above shows the value of 0,01 Hz, which means that it will take the command signal 100 seconds to go back and forth, or 50 seconds in one direction.
- [dy/dx]>D_____F(Hz) to enter the lower speed value when the D value is exceeded. The figure above shows a 10 time lower speed than the preceding one.

«Gén. DC AO1» direct current generator

The second analog output is provided with a DC generator. It generates a voltage output ranging from –10 to +10 V. This voltage may be used for additional functions.

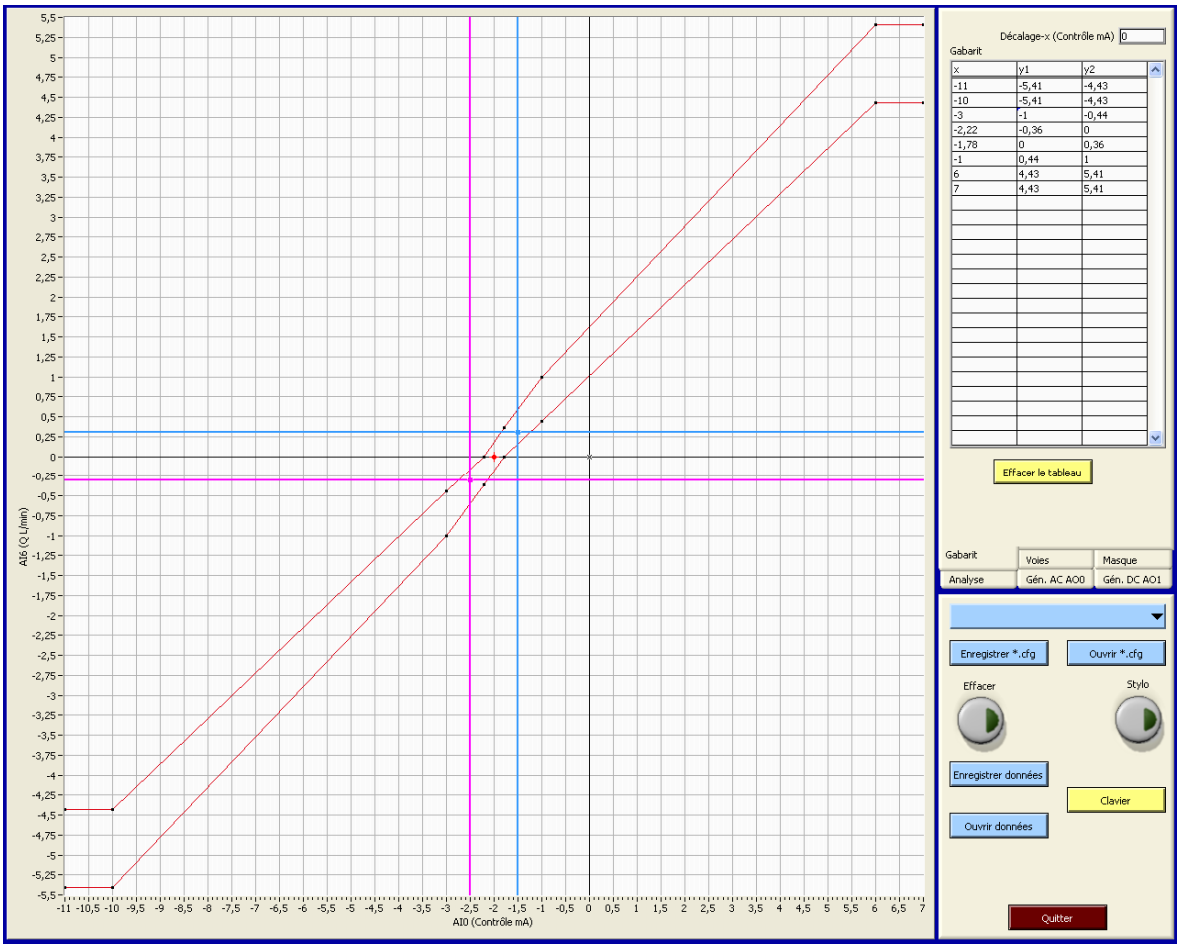


For example, this generator may be used to generate command signals for pressure supply in case the test rig has the pressure closed-loop feedback.

The output values may be entered by moving the cursor or typing digits with a keyboard. This is the case for all similar controls of these facilities.

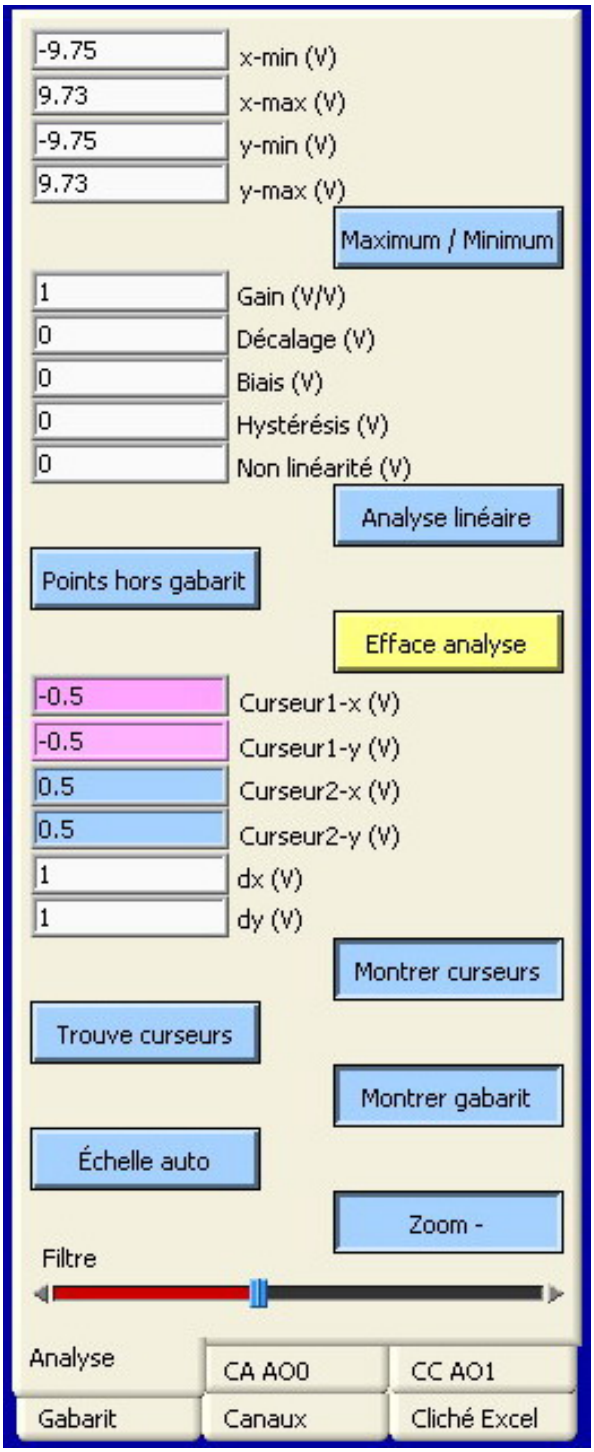
Tolerances

This page is used to enter the tolerance values which are given in the servovalve specification. These curves will form a part of the configuration of the envisaged test. The figure below exhibits tolerances for the flow test of a 1568 600-04 servovalve.



- The left column is intended for entering x values, in this instance the command signal current
- Both right columns are intended for entering the flow limiting values so that the actual flow curve shall be enclosed within these limiting curves. The values for the lower limiting curve shall be entered into the column y1. The inversion of this order will not change the diagram view, but the analysis of the test results provides for typing fat the out-of-tolerance points. In case of the inversion of the prescribed order this function will be disabled.

Analysis



After having run the test, you start analyzing its results.

«Maximum/Minimum»
When you press this button, a frame appears on the diagram showing the maximum and minimum values as test results on both axes.

«Analyse linéaire»
When you press this button, the computer displays some values of the plotted curve, namely:

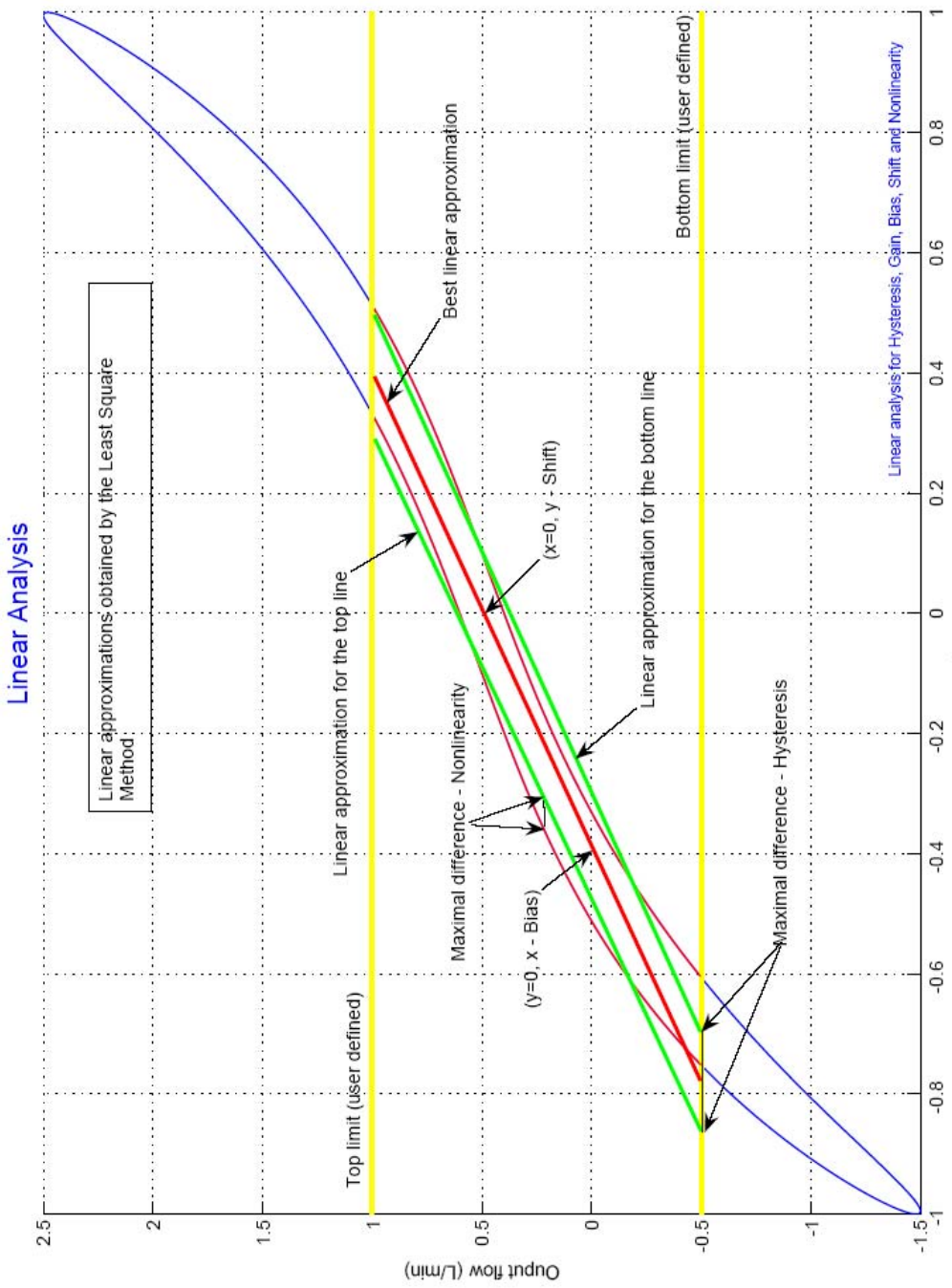
- Gain and null shift: the operator having placed both cursors of the y axis in the way to require a linear analysis between these two values, the computer will plot a linear curve as the best approximation of the measured curves (or the average line between two curves). This line is described by the following equation y=ax+b, where a is the gain value, and b is the null shift.
- Null bias
- Hysteresis, which is the maximum difference between the measured curves
- Non-linearity, which is the maximum difference between the direct computer-approximated line and the measured curves .

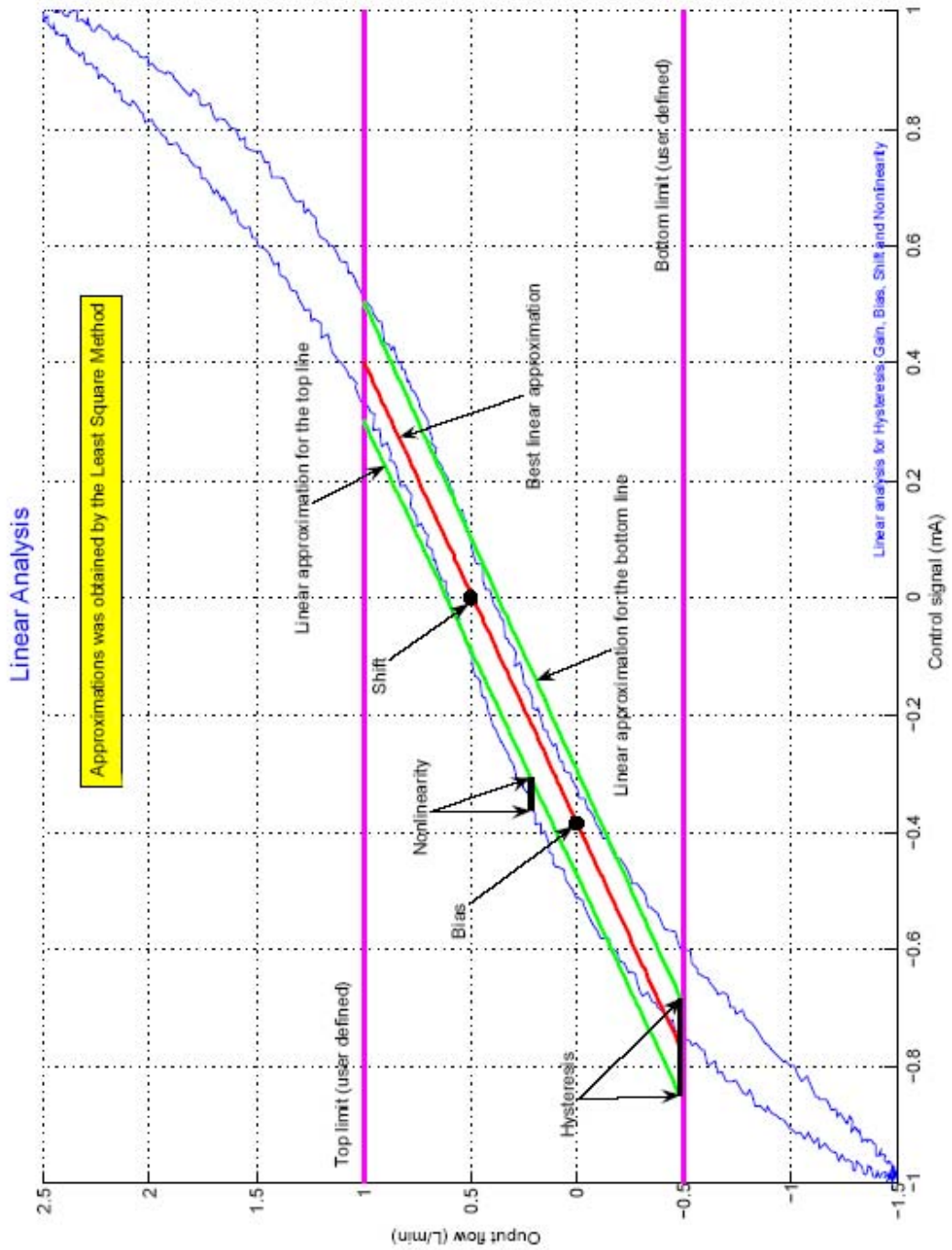
«Points hors gabarit»
When the tolerance values are entered, it is possible to type fat the out-of-tolerance points.

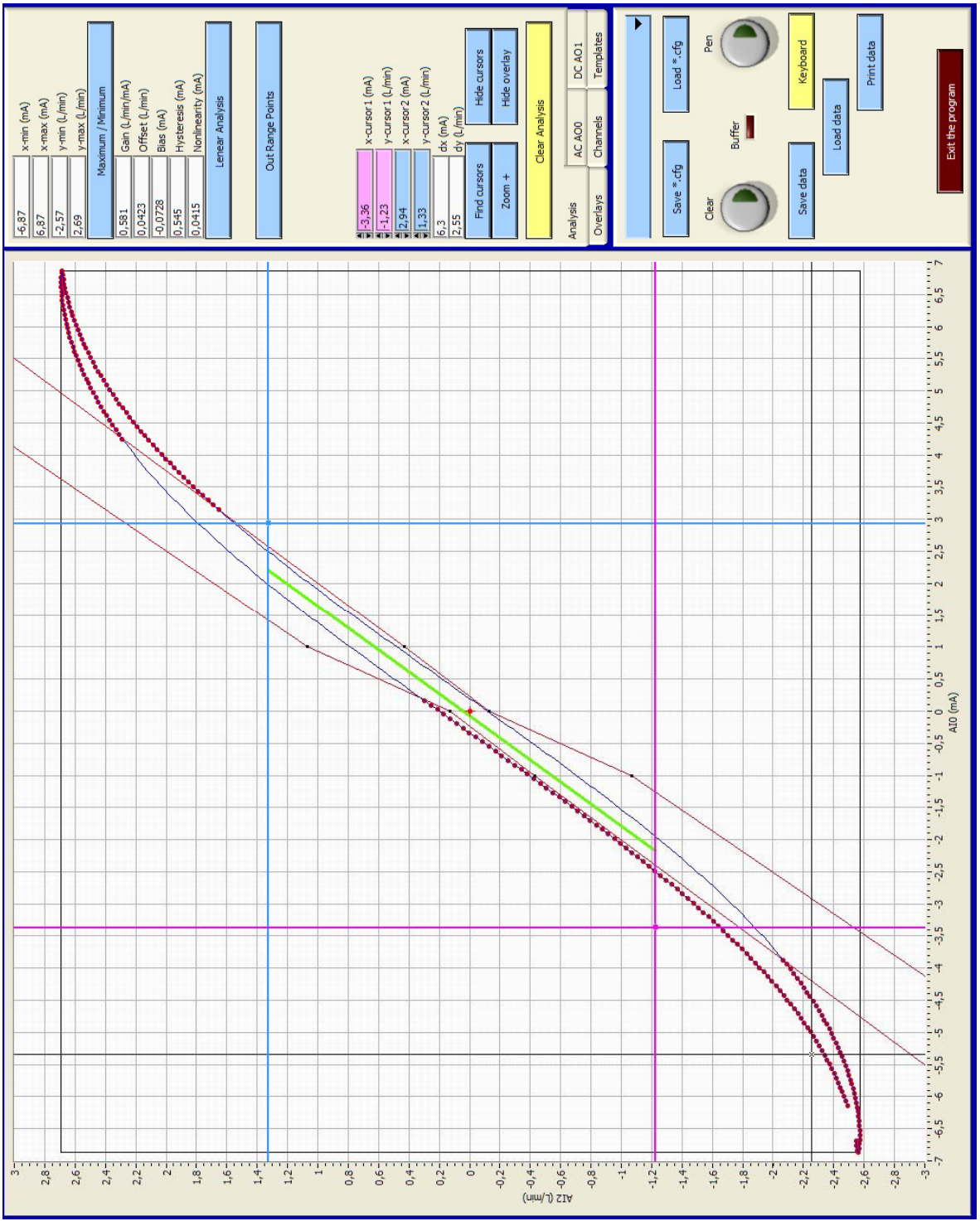
«Efface analyse»
With this button it is possible to delete the analysis. However, the results will not be lost. You have only to press «Analyse linéaire» or «Maximum/Minimum» buttons to let them re-appear on the diagram.

«Filtre»
A low pass filter is available. By moving the cursor, you may enter the cut-off frequency.
It is possible to define this frequency before or after measuring, and for every measured parameter particularly. For example, it is possible to filter the supply pressure measurement without affecting the flow measurement thus making pressure values easy to read on the display.

Two following pages show two diagrams with details of the described analysis.


Linear Analysis
Linear approximations obtained by the Least Square Method:
Linear approximation for the top line
Top limit (user defined)
Best linear approximation
Maximal difference - Nonlinearity
(y=0, x - Bias)
(x=0, y - Shift)
Linear approximation for the bottom line
Bottom limit (user defined)
Maximal difference - Hysteresis
Linear analysis for Hysteresis, Gain, Bias, Shift and Nonlinearity
Ouput flow (L/min)
Control signal (mA)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

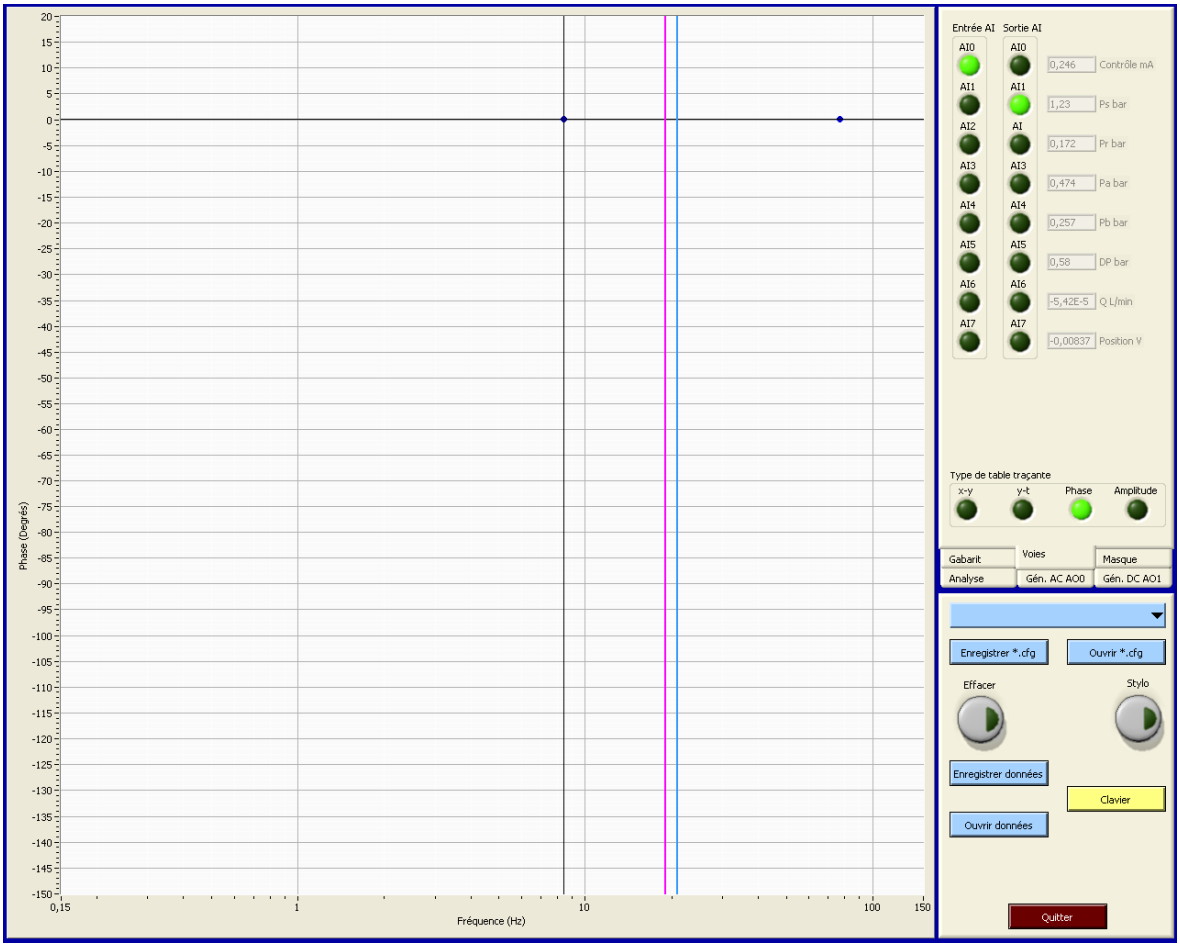

Linear Analysis
Approximations was obtained by the Least Square Method
Linear approximation for the top line
Best linear approximation
Linear approximation for the bottom line
Top limit (user defined)
Bottom limit (user defined)
Shift
Nonlinearity
Bias
Hysteresis
Ouput flow (L/min)
Control signal (mA)
Linear analysis for Hysteresis,Gain, Bias, Shift and Nonlinearity



This figure shows the linear analysis diagram with exhibiting points which are out of tolerances.

Frequency response

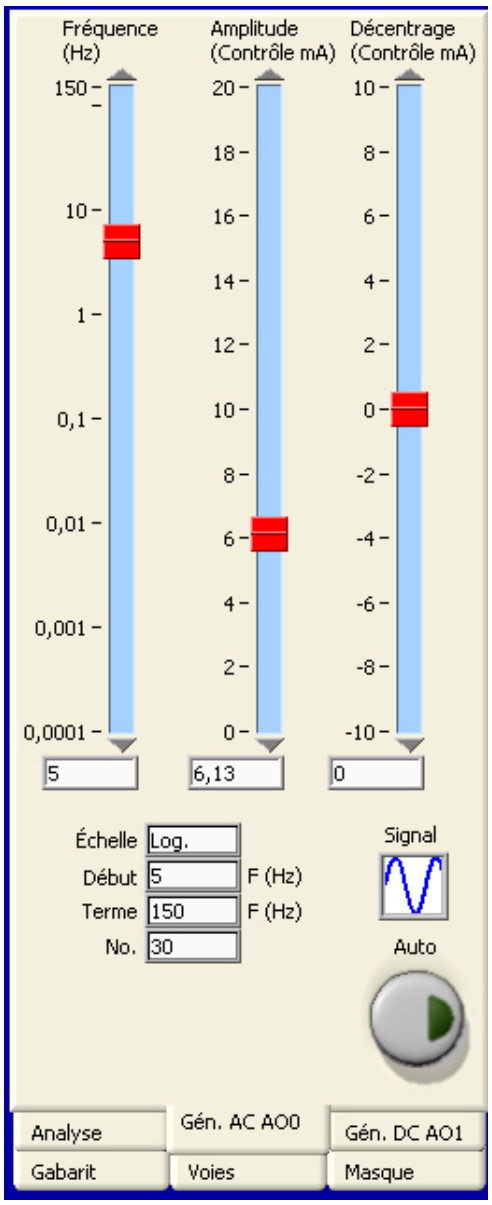
These facilities allow to measure the frequency response of the servovalves. Two curves may be drawn: phase curve as a function of frequency and amplitude curve as a function of frequency. A manual test is also possible in case you need only to read the phase value at a given frequency.



This figure shows a phase lag diagram as a function of frequency. AI0 input was used for entering command signals to the servovalve, AI1 input was used for spool position transducer signals. X axis is calibrated for frequency in Hz while y axis is calibrated for phase lag in degrees.

Each measured value is marked with a black point. The diagram above shows only 2 points having the same phase angle. An automatic test will produce a Bode diagram with a number of points as a function of the number of measurements.

The AC generator page will look differently for the frequency response test.

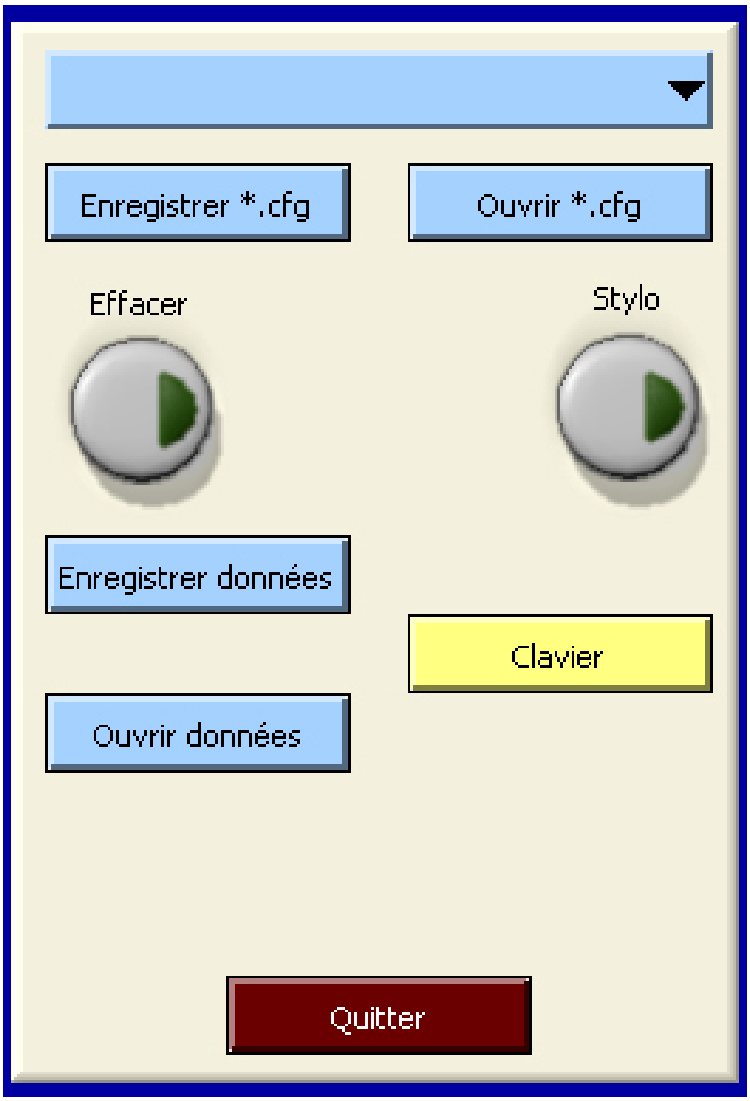


The following controls are available:

- «Signal», this function is disabled since the frequency response is measured with sinus wave signals only
- «Echelle», to calibrate the x axis either in linear either in logarithm values
- «Début», to set the lowest frequency for starting measuring the frequency response. This states by definition the amplitude ratio to be null at this frequency
- «Terme», to set the highest frequency for stopping measuring the frequency response
- «No.», to set the number of measurements to be done for drawing the Bode diagram
- «Auto», to begin measuring the frequency response.

Save and templates

Test configurations may be saved, as well as the results of the tests which are already run

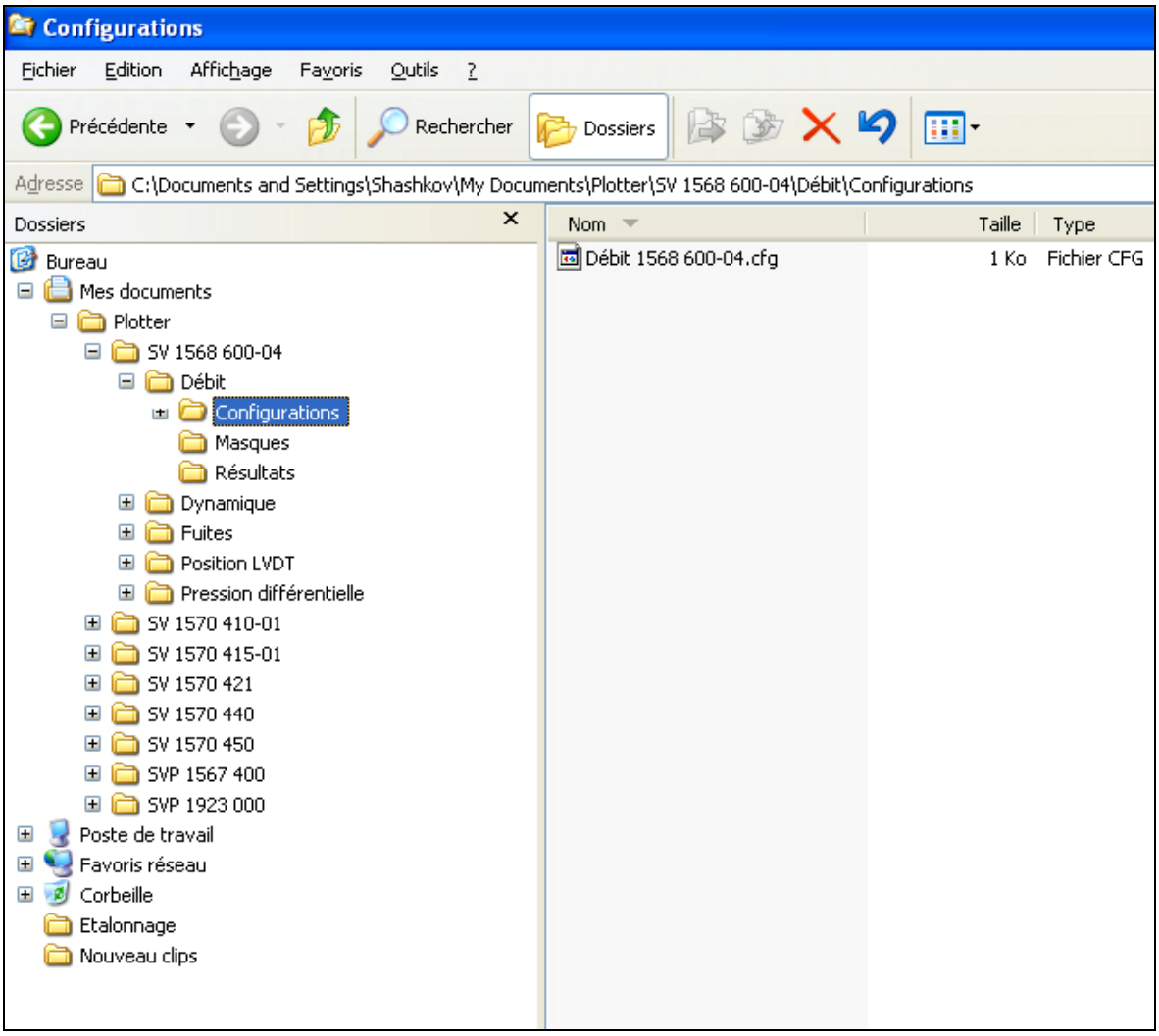


1) Test configuration saving

To make a test configuration, you have to:

- Choose the measurements to do and attribute inputs and outputs
- Make calibrations
- Set tolerances
- Set the speed of the command signal change-over
- Set the print-out masque

It takes a certain time to make a test configuration, and this time is rather long. As we test only a ten of servovalve models, we may create files attributed to each of them. It is a suggestion, but the operator may use another way of saving different configurations. For example, it is possible to save the configuration for testing one servovalve model and to manage its use with Windows Explorer.

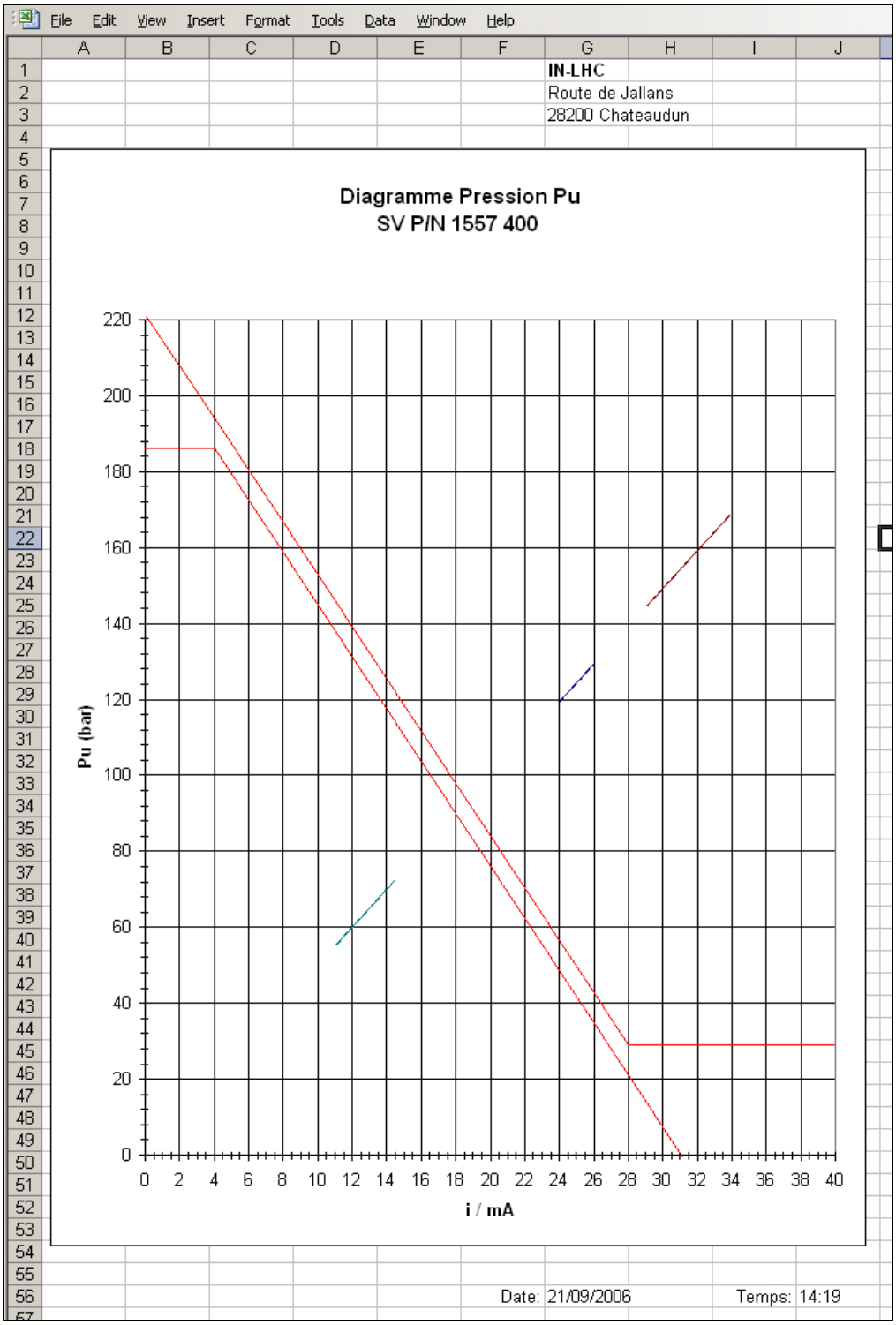


For example, the Plotter directory encloses different configurations to test a SV 1568 600-04 servovalve model. For measuring its flow curve, the test configuration is saved as well as the configuration of the print-out template which produces the test results as Excel diagram that is used to save them and print out.

When you need to measure the flow curve of this servovalve, you open Débit 1568 600-04.cfg. All saved settings and configurations will take their places, and you may start testing.

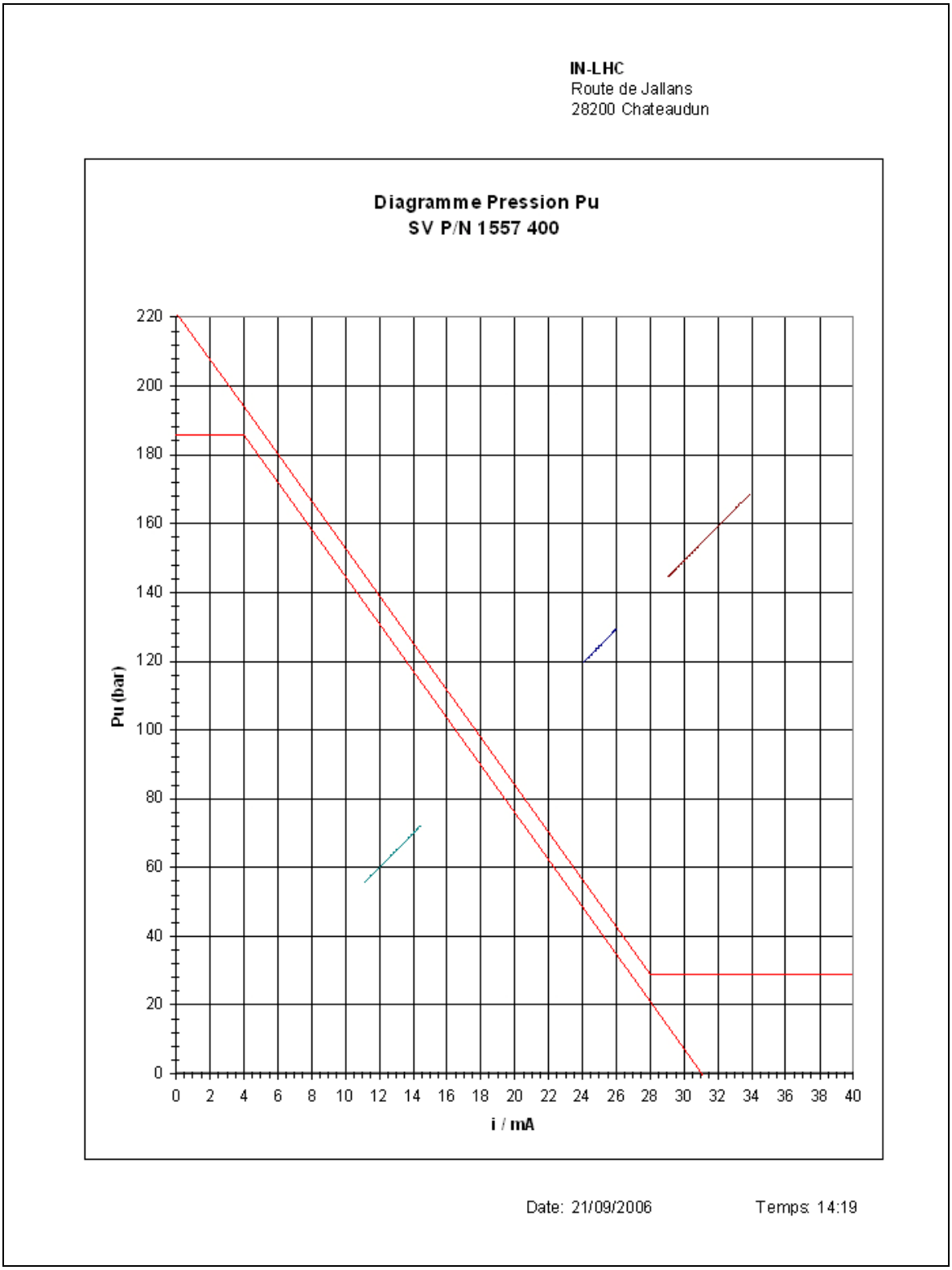
Having finished the test, you ask to save the results. This time you name the file and point out the directory where the file will be put in. In case of a multi-curve diagram, as for some pressure control servovalves, it is necessary to attribute Excel sheet pages to each curve to be saved. These pages may be named as Data 1, Data 2, Data 3 and so on. When pressing the button Enregistrer données, the data are transferred to an Excel file, which opens at once. Now you may save them or print out.

With Excel provisions, it is possible to make corrections or changes on the open page.

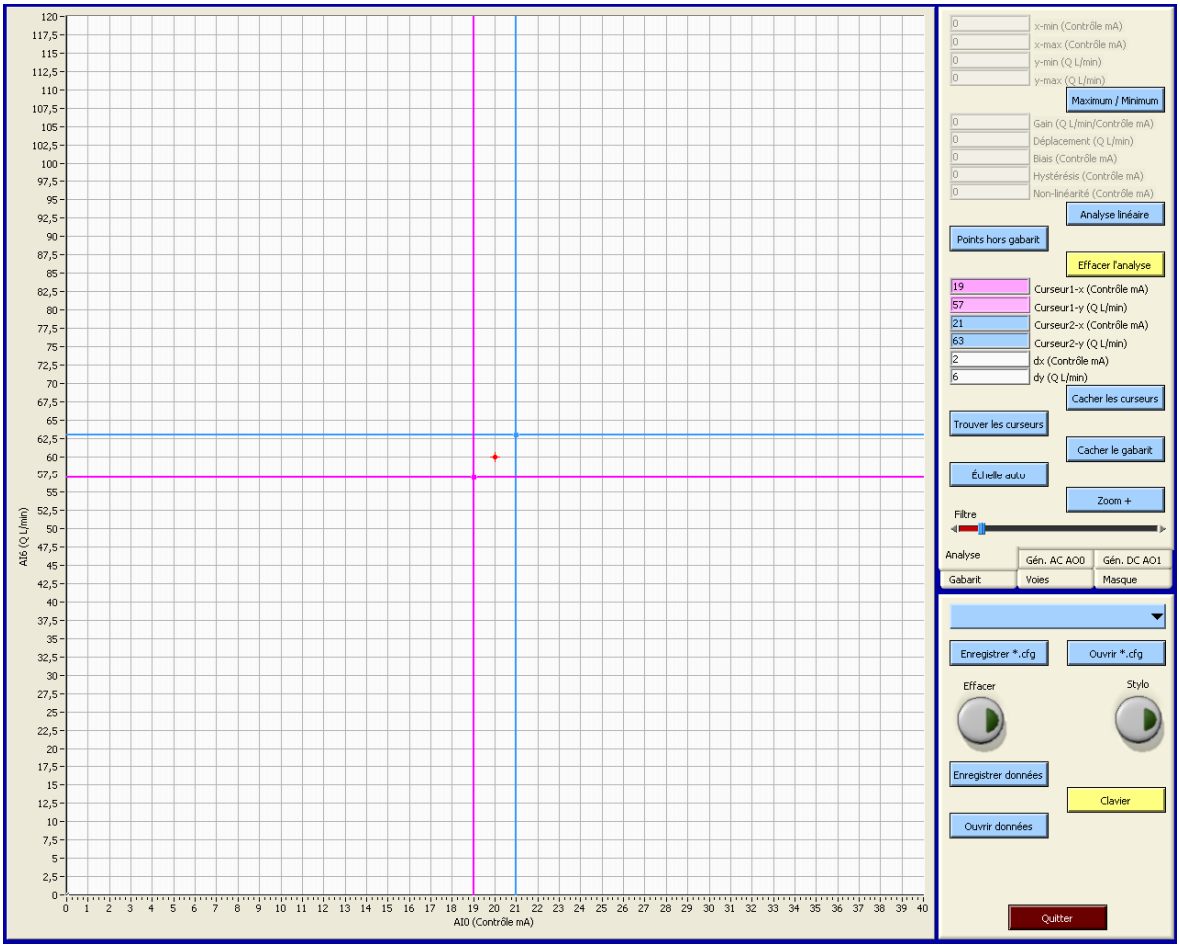


The figure above shows a three curve diagram where the measured flow curve is blue, the computer-approximated line is green and the tolerance boundaries are red.

Being satisfied with Excel presentation, you may start saving the diagram or printing it out. The figure below shows the diagram print-out.



Additional functions

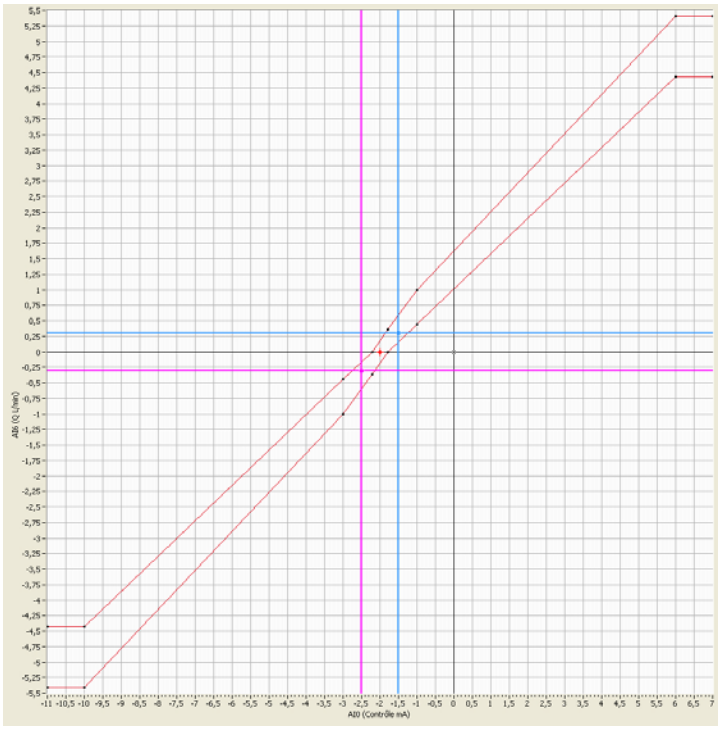


To make the test running easy, some additional functions are available, namely:

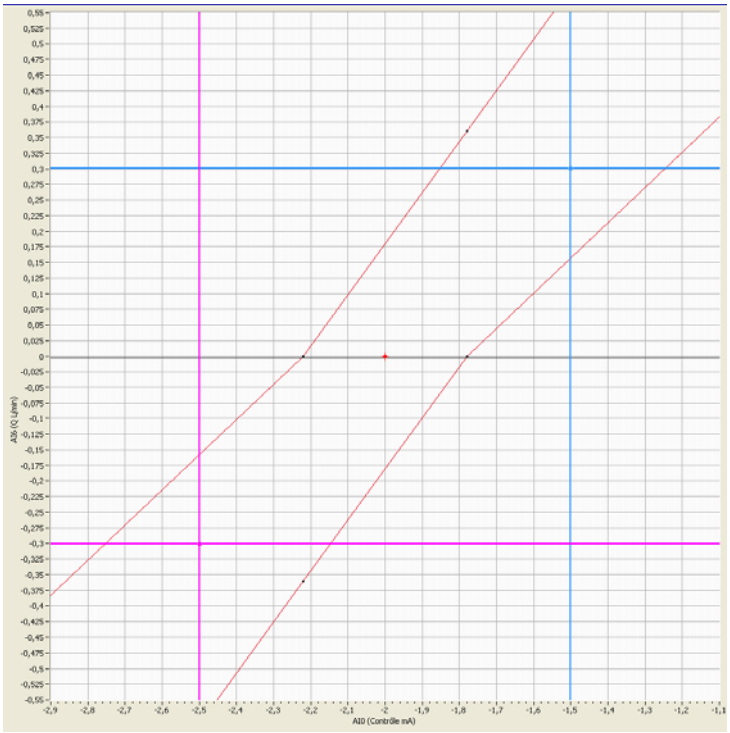
- «Trouver les curseurs». It happens that the cursors are out of the window frame. Pressing this button places the cursors in the center of the window.
- «Cacher les curseurs». Pressing this button causes the cursors to disappear if they trouble.
- «Cacher le gabarit». Pressing this button causes the tolerance boundaries to disappear. They may be displayed at any moment.
- «Echelle auto». In case when the flow of a servovalve was measured with a reduced range of command signals it is not necessary to re-adjust settings for the flow and command signals. Pressing this button causes the flow curve to be drawn at a full range of signals.
- «Zoom+». The red point in the center of the diagram may be moved anywhere. Pressing this button causes the curve portion marked by this red point to be zoomed in thus allowing to examine it closer.
- Each cursor is positioned by entering the desired digits, as well as the differences between them which are defined as dx and dy.

Zoom

Full scale diagram:

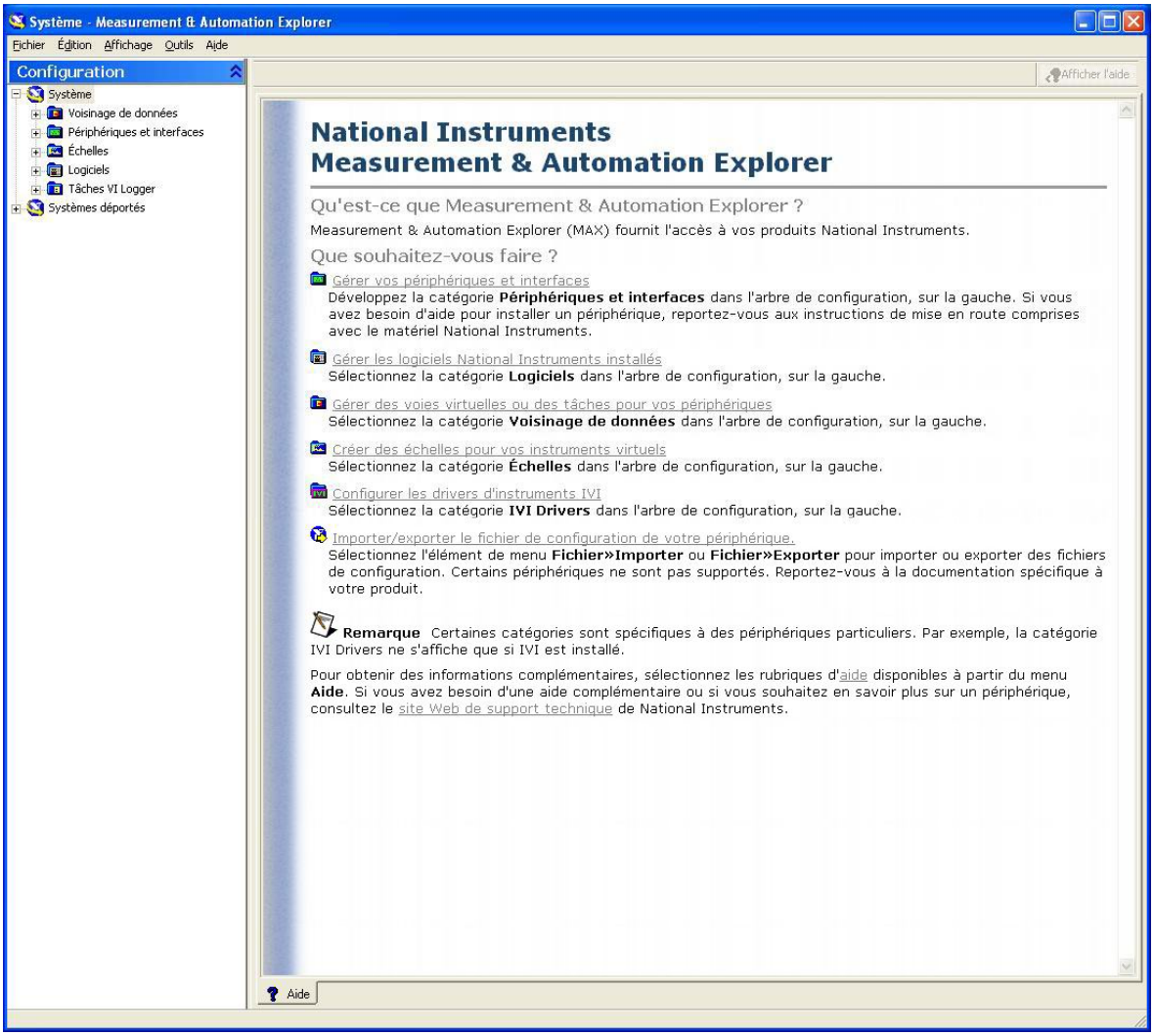


The red point is in the center of the diagram. This point may be moved anywhere on the diagram. Pressing the zoom button causes the diagram to be zoomed in as shown below.

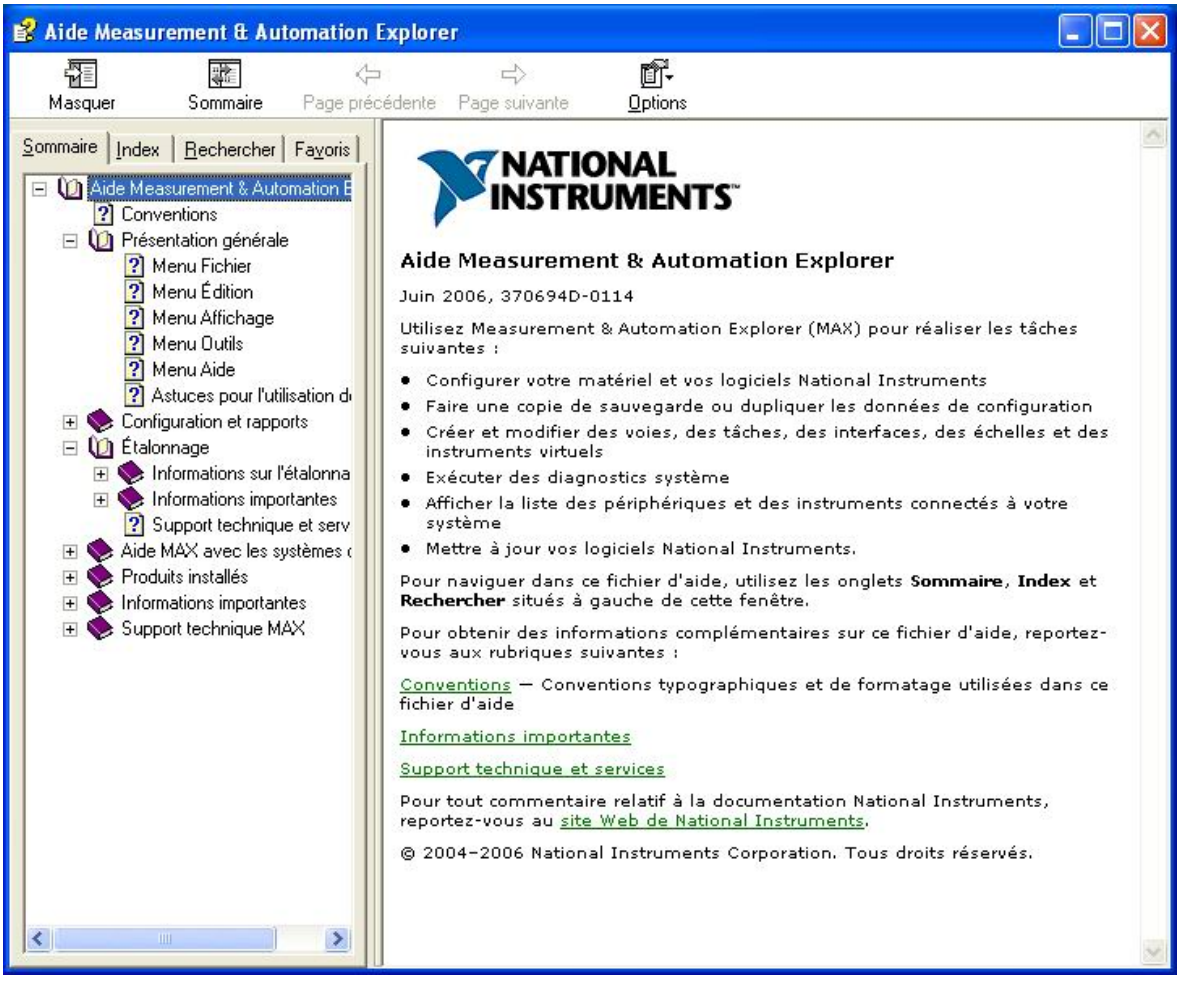


Calibration

Each test rig shall be calibrated.
The National Instruments Measurement & Automation Explorer software is used.



An Aide software is available.



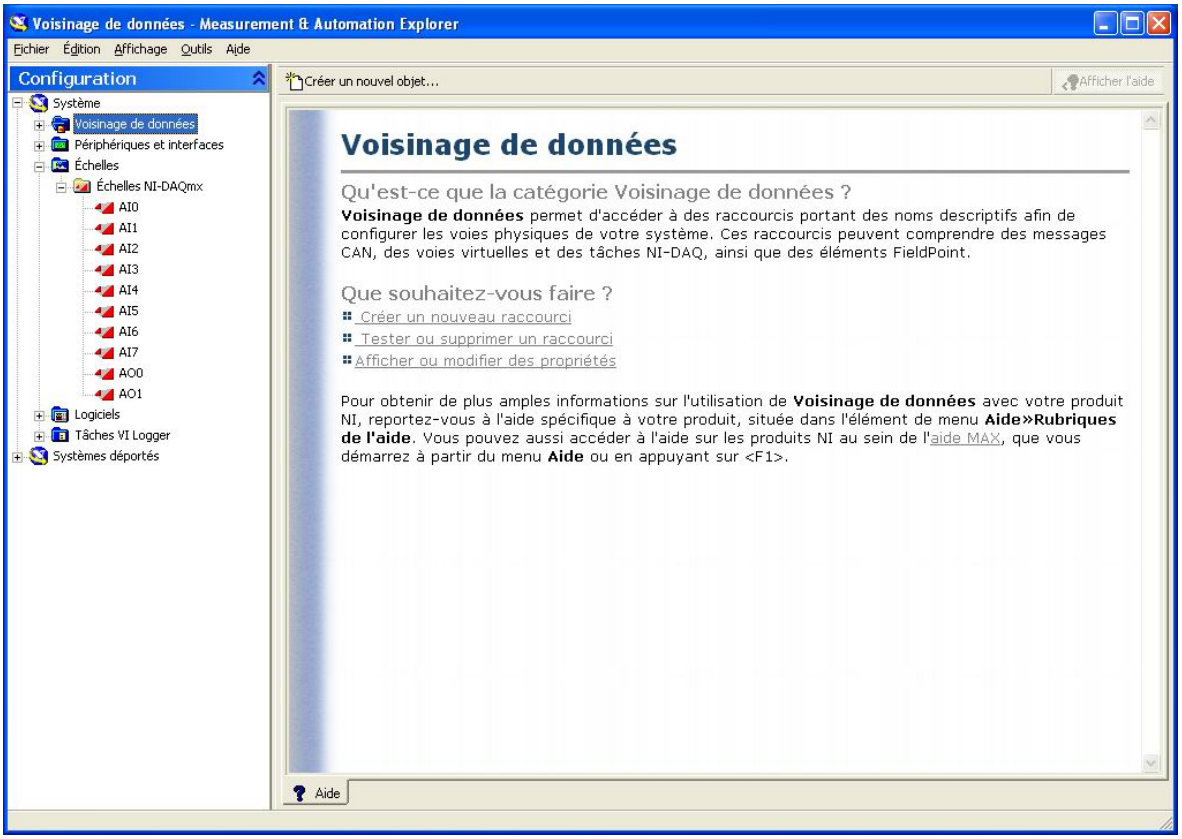
This Aide software explains the calibration procedure. The main actions to be done are briefly described below.

It is necessary to open two directories, namely:

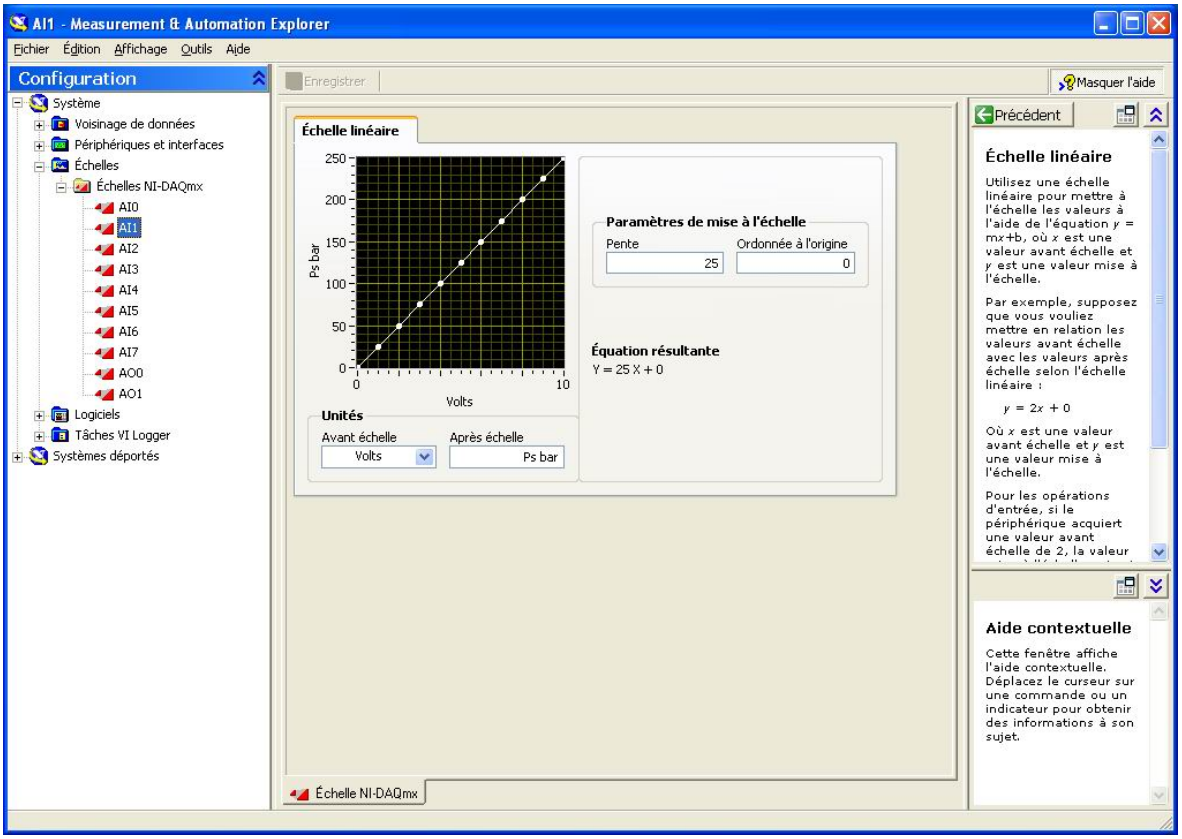
- Voisinage de données
- Echelles

Scales

Let us begin with the Échelles directory.
It is necessary to define the scales of each parameter to be measured with this test rig and for the kind of test which will be run.
Let's assume that the AI1 input is attributed to the rig supply pressure.
We open the Voisinage de données directory, then we open the Echelles directory and finally we open the Echelles NI-DAQmx directory.
We will see cells for each analog input from AI0 to AI7 and for both analog outputs AO0 and AO1.



We open the AI1 cell.



The AI1 input is attributed to the supply pressure which we index as Ps.

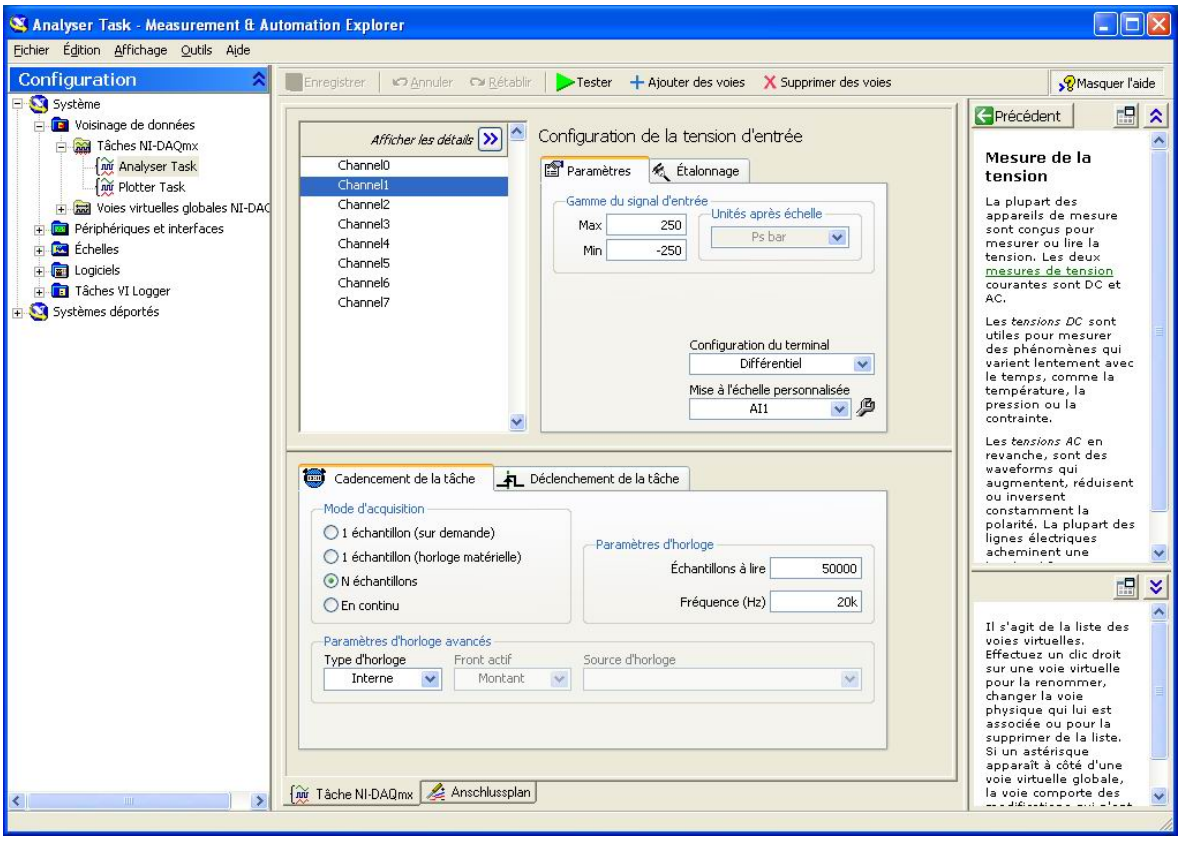
We name this scale Ps bar. This name will appear on the input/output page and tell that AI1 input corresponds to the supply pressure and is calibrated in bar.

Signals are measured in Volts, and this is to be set.

If the pressure transducer performance is linear, its slope and initial ordinate will be attributed according to the following equation:
Y=ax+b,
where a is the slope, and b is the initial ordinate.
Let's assume that the pressure transducer generates a 10 V signal for 250 bar. We enter 25 into the Pente cell (25 bar/V). If the pressure transducer has no zero drift we enter 0 into the Ordonnée à l'origine cell.

If the pressure transducer performance is not quite linear, it may be corrected. It happens very seldom, however these facilities have a correction function..

The procedure is not yet over.
We have to do other settings for each parameter to be measured. So, we open the Tâches NI-DAQmx directory, and then the Analyser Task directory. The following page will open:



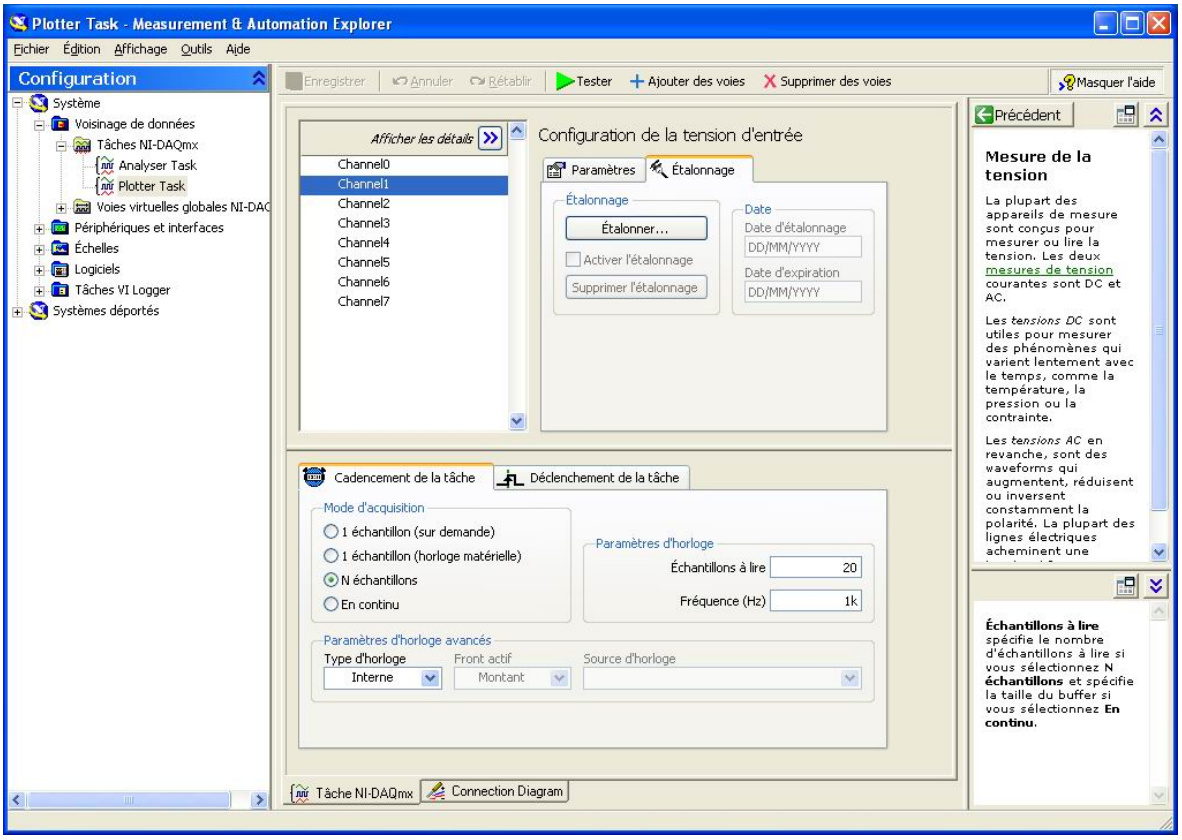
We have stated that the AI1 input will be used for supply pressure. Now it is necessary to set the pressure boundaries. The pressure transducer having a range of 250 bar, we enter 250 as a maximum value for the pressure command signals. If during the test the pressure exceeds this maximum value the software will stop testing.
We enter –250 as a minimum value for pressure command signals. Certainly, the pressure can not be negative but if we limit it to zero value the test will be stopped in case of the lowest negative noise signal.

Then we enter the measurement settings.
For example, we envisage 50000 measurements, and the measurement frequency is 20 kHz.

Plotter settings

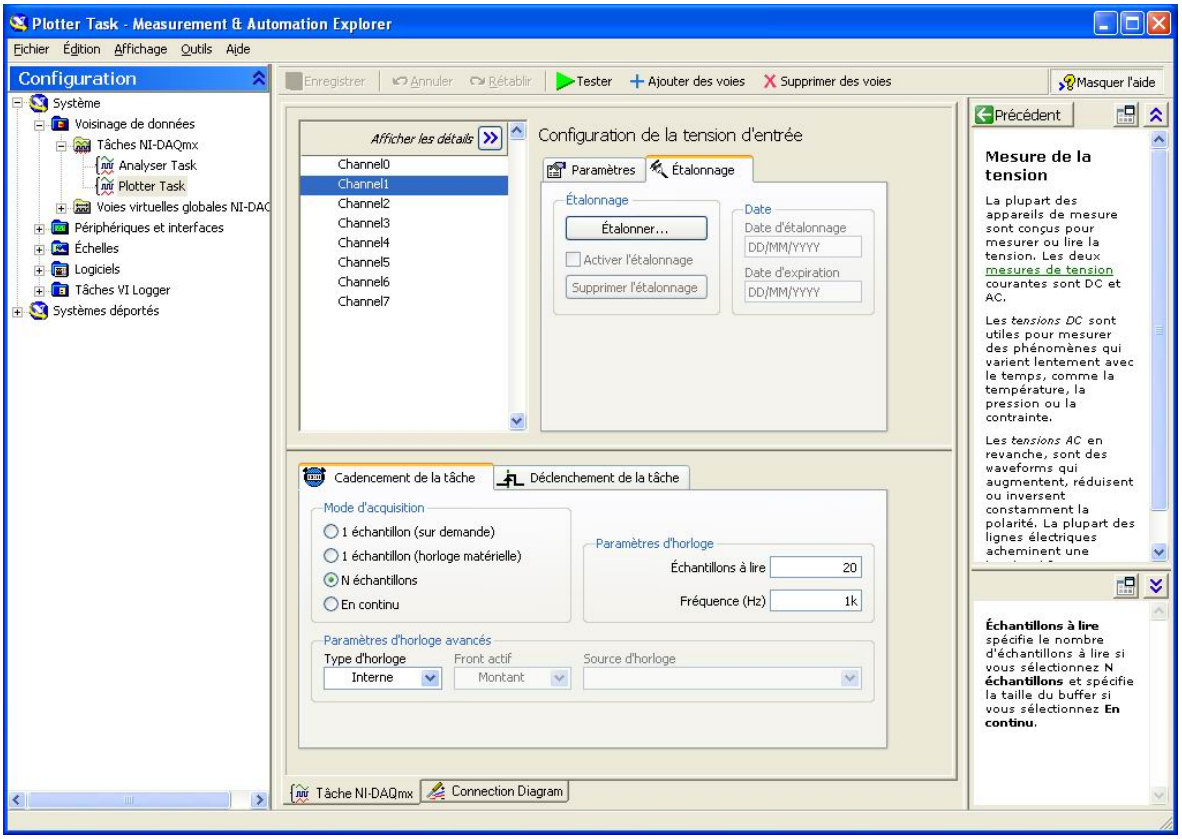
Measurements result in the curve plotting on the display. It is necessary to define the plotter parameters as well, namely:

- Maximum and minimum limits
- Number of measurements
- Frequency of measurements

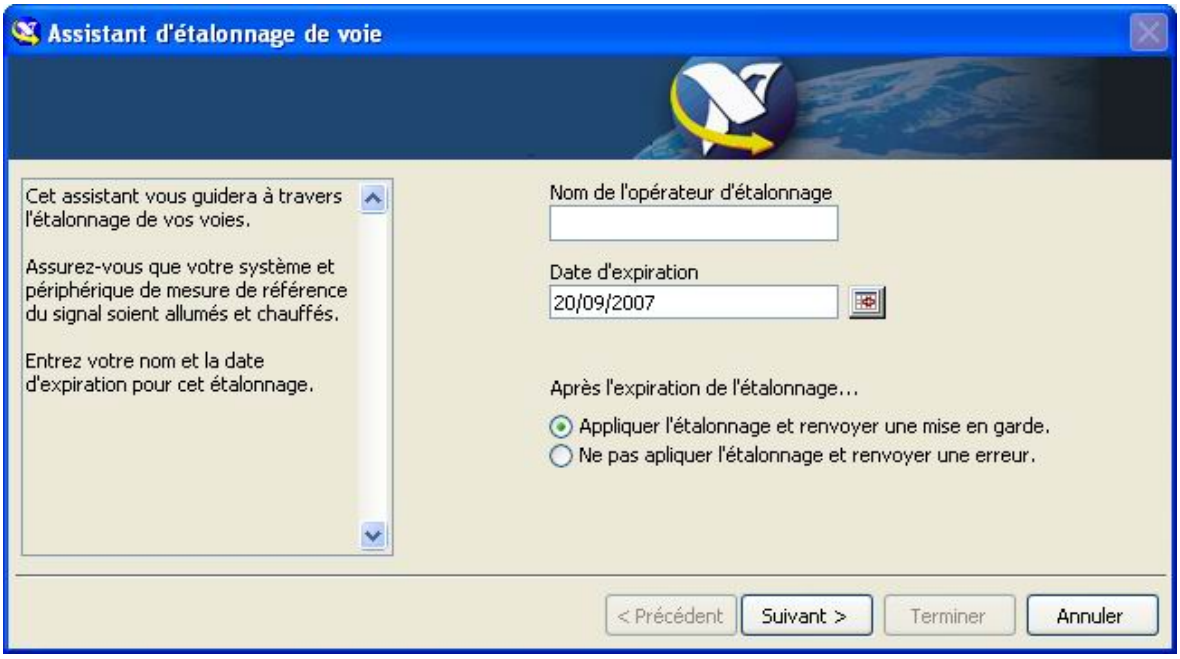


Having done it for every measured parameter, a calibration report may be made up and memorized.

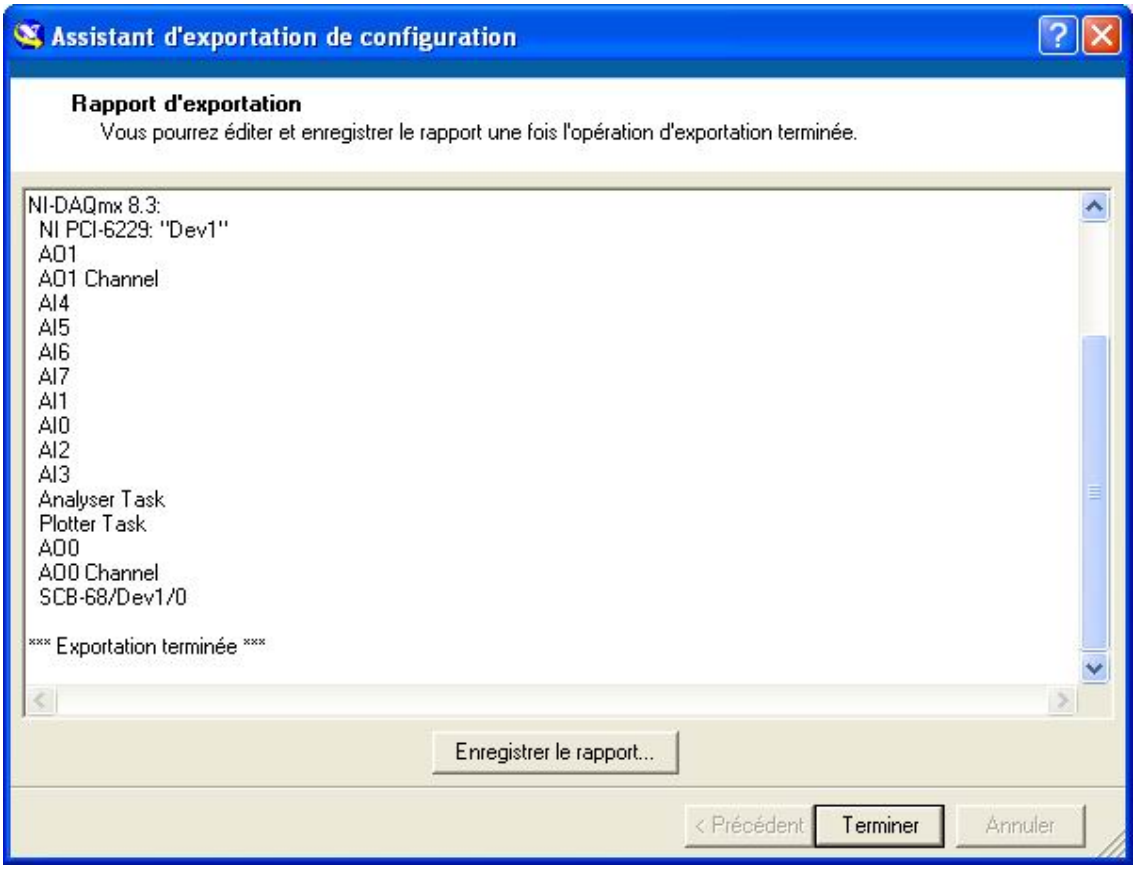
Finally, it is possible to enter and save the calibration date and the name of the person who has done this calibration.



And to set the calibration expiry date.

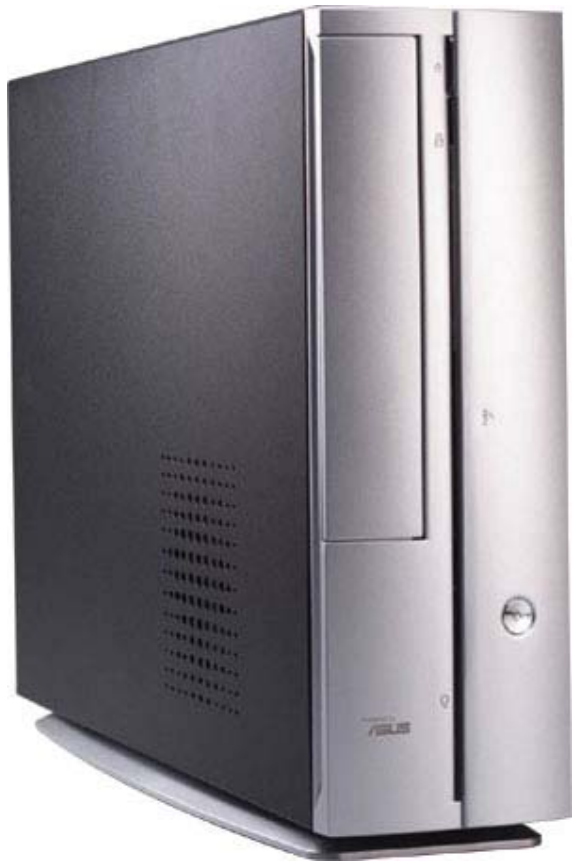


Now it is time to save the calibrations for the test rig for which these settings were intended. In case only one plotter is available it is possible to calibrate it for several test rigs.



Hardware

Micro-computer (PC)



Asus Pundit-R350 Platform computer

Intel Pentium 4,3 GHz microprocessor

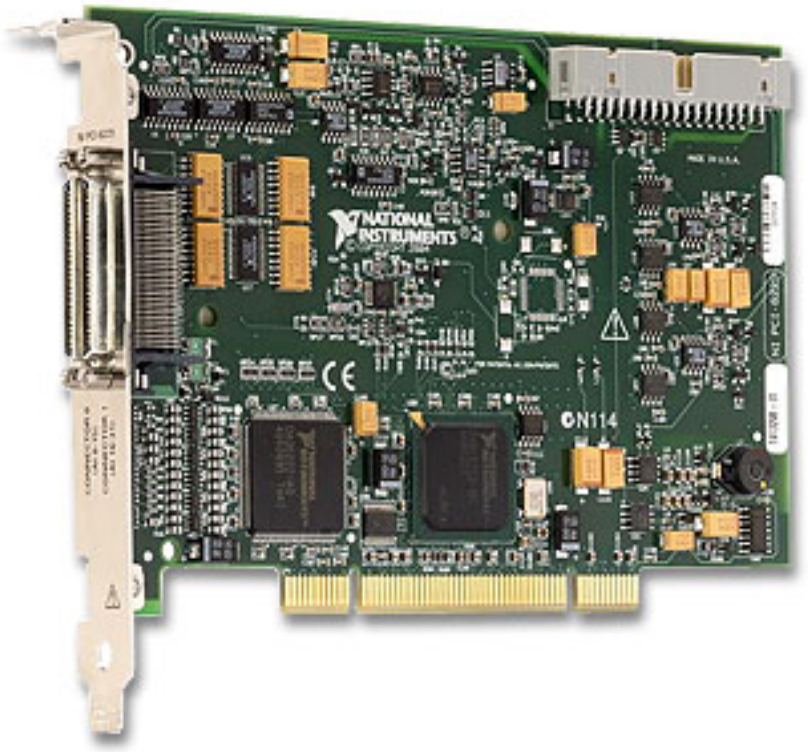
RAM 512 MB

HDD 160 GB hard disc

NEC16xDVD+/-RW compact disc driver

MS Windows XP software

DAQ
Data acquisition card



National Instruments M-Series PCI-6229:

- 16 differential analog inputs, 500 kHz 16 bits
  (only 8 analog inputs will be used, one of them being intended for command signals generated by the test rig potentiometer)

- 4 analog outputs, 833 kHz, 16 bits
  (an output will be used for command current to be applied to the servovalve)

- 2 counters, 32 bits
  (they may be used to measure the flow with VSE flowmeters)

- 48 digital inputs and outputs

BNC interface card with housing and connectors

Screened cable

ELOET 1939L, 19’’ monitor
It is a tactile monitor with rear mounting plate.
It has a tight injection moulded housing. It may be used in a rude environment and serve as a command desk by touching (thus replacing the mouse and the keyboard).
The monitor provides:

- angle of vision 170° x 170°
- brightness 250 cd/m^2
- contrast ratio 1000:1
- resolution 1280 x 1024

HP DeskJet 5940 printer

Printing speed in draft mode 30 pages/minute
Printing quality 1200 x 1200 dpi
Capacity 100 pages
Memory 4 MB

Logitech keyboard and mouse (cordless)